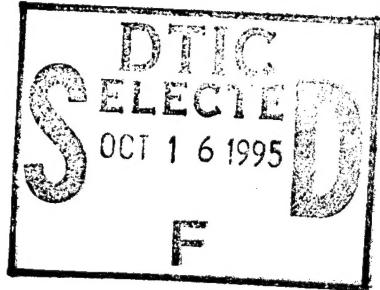


**FIELD EMITTER ARRAY BASED DICKE SWITCH ARRAY FOR MM-WAVE**

**RADIOMETRIC SYSTEMS**

Contract No: N00014-94-C-0243



**MONTHLY REPORT NO. 4**

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**DISTRIBUTION STATEMENT A**

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**OBJECTIVE:**

The objective of the Phase I program is to build a revolutionary new concept for providing quasi-optical Dicke-switch array that is light weight, has low power consumption, and uses conventional low-cost technology to produce. The quasi-optical switch array is currently being developed for large area displays.

**PROGRESS:**

During this month of the Phase I program, the design of the Quasi-optical array has been completed. Initially the switch structure will be implemented and tested at 30 GHz , without the switching , to determine the transmission characteristics of the switch array. This will form the basis of comparison when the switching mechanism is introduced. During this period the DC characteristics of the switch has been measured.

**SUMMARY OF THE OVERALL APPROACH BEING USED TO IMPLEMENT DICKE SWITCH ARRAY TECHNOLOGY.**

A unique and innovative plasma based switch is developed in order to implement a Dicke Switch Array. The overall structure as shown in Figure 1. A highly conductive plasma is used to link and connect adjacent pads of the array is made to be very low resistance allowing very small signal levels to be processed without significant losses. However, when the plasma is turned-off, the inter-pad space is essentially an open switch that has extremely high impedance. The plasma based switching technology is also expected to provide very high power switching capability. The plasma devices being under development at Princeton Microwave Technology have the potential to provide low cost, multiple

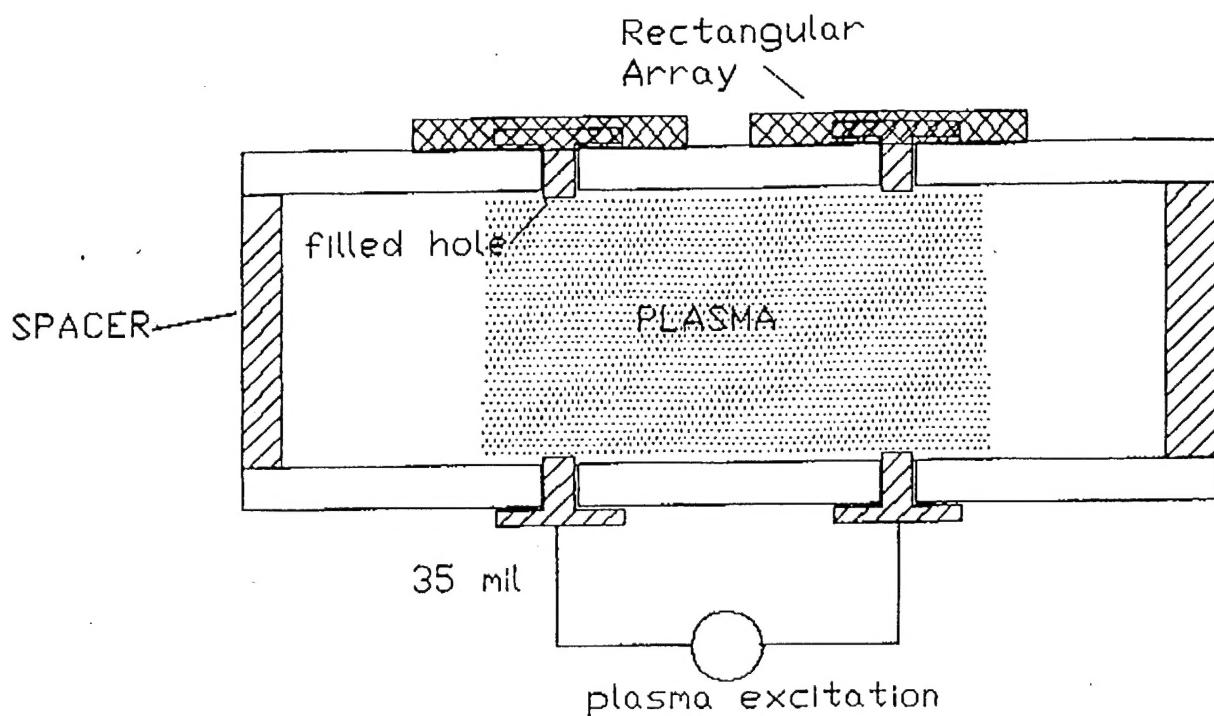


Figure 1: PLASMA BASED SWITCH FOR DICKE ARRAY

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switching arrays similar to that used in plasma based flat panel displays. Our plasma devices will finally be optimized to be more electrically efficient and designed to ensure a very low "on-resistance". Two approaches are being currently evaluated to achieve this low on-resistance will be achieved by use of diamond.

1. Use of low work function or negative electron affinity (NEA) electron emitting coating on the plasma excitation electrodes and employing dc or low frequency plasma excitation.
- or
2. Minimization of the plasma discharge impedance by using high frequency plasma excitation.

Thus, the development and optimization of the plasma based switches is an crucial item in this program.

### **Development of Plasma Switch**

During the last month we focused on developing and initial optimization of the plasma switches to be used. In this report we will describe the approaches and operating characteristics of the high frequency plasma switches. The experiments carried out this month were basic to operating characteristics of these devices.

### **Plasma Excitation Details**

The initial plasma switches to be evaluated were fabricated consisted of planar structure fabricated on 4 inch diameter silicon wafers. This substrate was chosen because it allowed ease of fabrication. Once the switch configuration is optimized the configuration will be implemented in a microwave suitable substrate

such as glass or ceramic. As an initial configuration, we deposited a variety of tungsten electrode structures on Si wafers. A typical electrode structure is shown in Figure 1. The basic configuration consists of different electrode geometries that are essentially lines and small pads. Since semiconductor grade silicon has a fairly high conductivity, we need to apply a high quality dielectric to isolate the adjacent plasma switch electrodes and from the underlying substrate. The dielectric chosen for this purpose was thick silicon oxide. The oxide film is thermally grown using standard IC processing.

### **Electrode Details**

The electrodes can be any metal that is compatible with standard IC processing. As we wanted to operate the plasma at atmospheric pressure in air we employed tungsten electrodes to minimize the effects of long term erosion under repeated use. The tungsten film was one-micrometer thick and applied by magnetron sputtering in a conventional deposition system. The tungsten film were deposited on top a thick  $> 1$  micrometer thick silicon dioxide film. Tungsten electrodes of different geometries were deposited in order to determine optimal configuration. In the final device electrical power will be applied to the electrodes through via plugs. In the initial structures investigated electrical power was applied directly to the planar electrodes.

### **Plasma Excitation**

To investigate different plasma excitation schemes we also deposited an aluminum metallization layer on the back side of the silicon wafer. The electrical power was applied to the tungsten electrodes using contact probes. The RF power can be applied either between adjacent electrodes or between one electrode and the aluminium contact on the back of the wafer. At atmospheric pressure the plasma discharge is

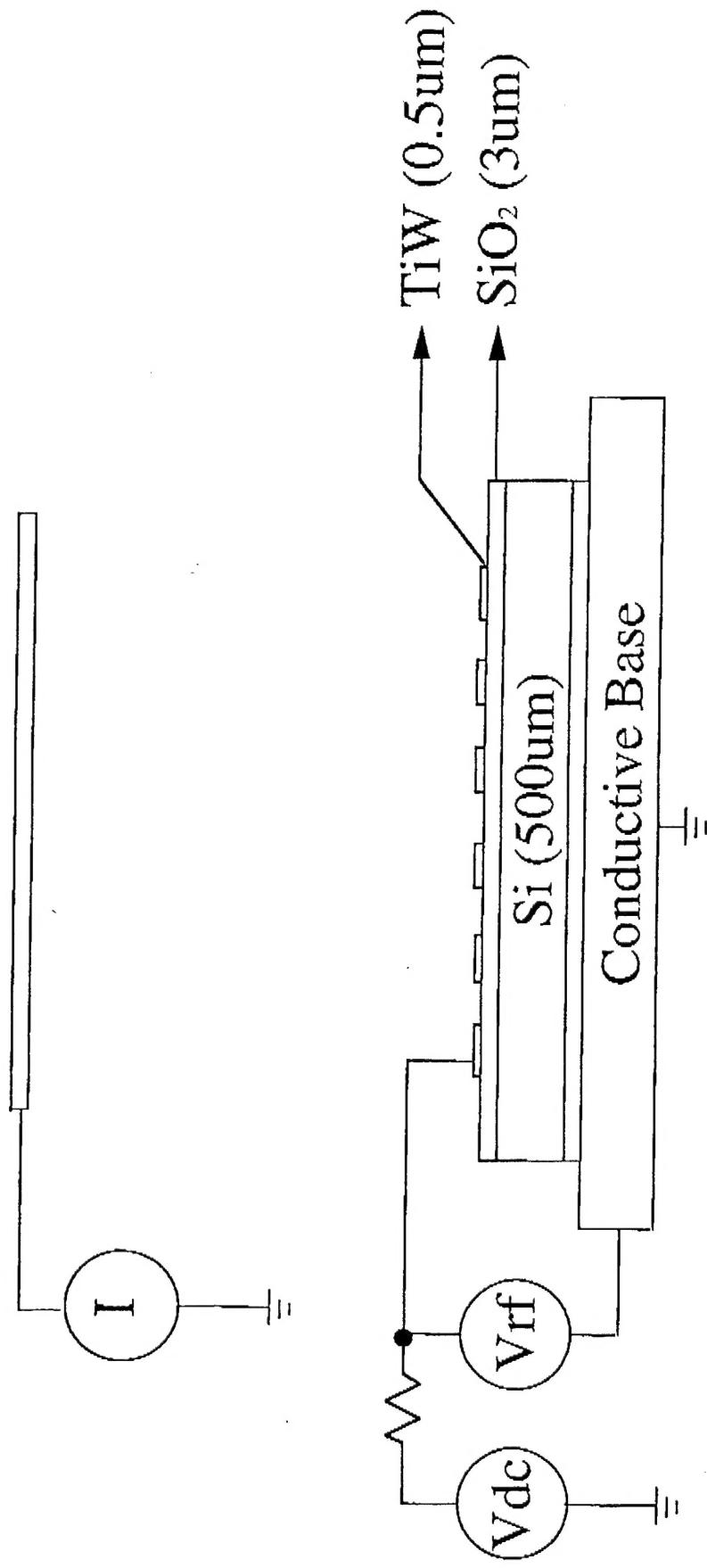


Figure 2.  
Operating Circuitry used to measure I-V characteristics

characterized a faint optical glow near the electrode surfaces. The plasma can be easily ignited. The plasma density and thus the plasma conductivity was changed by varying the excitation power. The peak-to-peak ac voltage of the excitation power depends, as expected on the electrode spacings. For electrodes separated by several mills approximately 100 to 300V ac is required. Lower voltages are expected when the electrodes are coated with NEA material such as diamond or when the electrode spacing is reduced.

A bias current was measured by placing a collection electrode opposite the driven electrodes as shown in Figure 2. A typical I-V characteristic is shown in Figure 3. These initial measurement appear to indicate that the plasma region can be expected to highly conductive. The next set of measurements that are underway will consist of the replacing the 'collection' electrode by two adjacent electrodes to simulate adjacent array pads. These measurements will be reported next month.

## **SUMMARY**

We have carried out initial configuration tests on a planar plasma switch structure. The plasma was easily ignited. It appears to be stable and is able operate continuously for a number of hours without deterioration of the material surfaces employed. The initial I-V characteristics indicate that this configuration is suitable for use as a switch. We will continue to investigate effects of electrode geometrics and effects of coating the electrode surfaces with NEA electron emitting materials to allow a low voltage plasma to be employed.

### Plasma Current vs Collector Electric Field

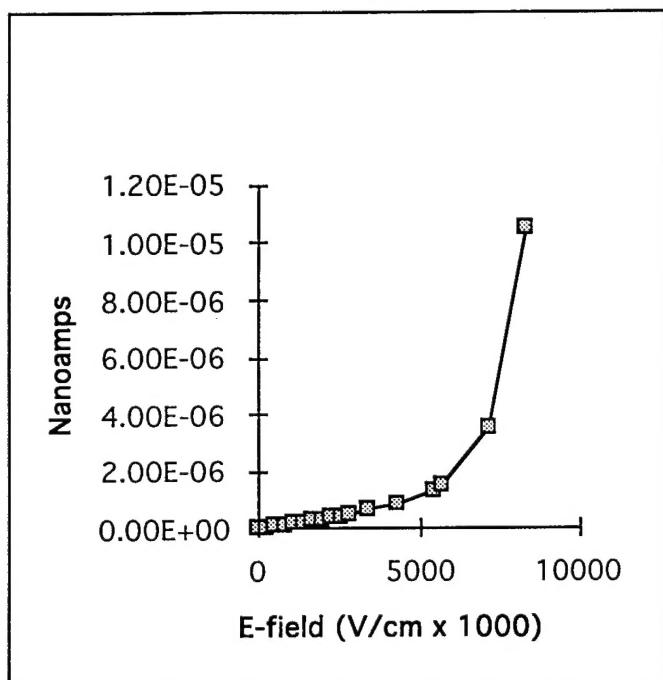


Figure 3